

GPS Re-Radiation System Technical Description

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Purpose of this application

The purpose of this application is to obtain a 2-year experimental license to operate a GPS re-radiation system supporting the test and development of GPS systems and equipment in experimental aircraft and payloads.

Why we are applying for a license

[Scaled Composites](#) is a proof-of-concept aircraft designer, manufacturer, and flight-test organization with more than 30 years' experience in developing and testing more than 30 groundbreaking and unique aircraft including those listed below and shown in Figure 1 - Selected Scaled Aircraft:

- Model 281 Proteus, currently used for high altitude research and payload development.
- Model 311 Virgin Atlantic Global Flyer, the first turbofan aircraft to fly around the world unrefueled (on display at the National Air and Space Museum).
- Model 316 SpaceshipOne, the winner of the Ansari X prize as the first private manned spacecraft.
- Model 326 Northrop X47A.
- Model 339 SpaceshipTwo prototype for the first manned commercial space system.
- Model 355 Firebird optionally piloted ISR vehicle.



Figure 1 - Selected Scaled Aircraft

Scaled conducts aircraft development, flight test, and system test out Hangar 78 at the Mojave Air and Space Port. These operations involve multiple aircraft and each aircraft has multiple GPS receivers and antennae.

In addition Scaled conducts experimental payload development and test in this hangar. The aircraft carry multiple payloads and many of the payloads have one or more GPS receivers and antennae.

The use of a GPS re-radiation system in this hangar is appropriate for these reasons:

- Scaled is involved in the test of GPS receiving systems as part of the development and test of aircraft, systems, and payloads.
- The number of aircraft, payloads, and GPS receivers and antennae in the hangar make indoor solutions like GPS “hoods” impractical.
- The aircraft and payloads are frequently immobilized (on jacks) or are otherwise unable to be moved outside the hangar during ground test and integration operations.
- The GPS re-radiation system will comply with all NTIA requirements.

Compliance with NTIA requirements

This installation will comply with all requirements stated in section 8.3.28 of the NTIA “Manual of Regulations and Procedures for Federal Radio Frequency Management (Redbook)” May 2013 edition: *Use of Fixed Devices That Re-Radiate Signals Received From the Global Positioning System.*

- Individual authorization is for indoor use only, and is required for each device at a specific site.
Operation will only be conducted indoors at the location identified above and as the station location in the application form 422.

- b. Applications for frequency assignment should be applied for as an XT station class with a note indicating the device is to be used as an "Experimental RNSS Test Equipment for the purpose of testing GPS receivers" and describing how the device will be used.
Scaled concurs with the XT station class. The description of device use is below in the section entitled "System use"
- c. Approved applications for frequency assignment will be entered in the GMF.
Scaled concurs with this requirement.
- d. The maximum length of the assignment will be two years, with possible renewal.
Scaled concurs with this requirement
- e. The area of potential interference to GPS reception (e.g., military or contractor facility) has to be under the control of the user.
Hangar 78 is under Scaled's control.
- f. The maximum equivalent isotropically radiated power (EIRP) must be such that the calculated emissions are no greater than -140 dBm/24 MHz as received by an isotropic antenna at a distance of 100 feet (30 meters) from the building where the test is being conducted. The calculations showing compliance with this requirement must be provided with the application for frequency assignment and should be based on free space propagation with no allowance for additional attenuation (e.g., building attenuation.)
Calculations are supplied below in the section entitled "System technical description" and comply with this requirement. The computations include no allowance for additional attenuation.
- g. GPS users in the area of potential interference to GPS reception must be notified that GPS information may be impacted for periods of time.
Scaled will comply with this requirement. We will also notify the relevant Mojave Air and Space port personnel.
- h. The use is limited to activity for the purpose of testing RNSS equipment/systems.
The use of this system will be limited to testing RNSS equipment and systems.
- i. A "Stop Buzzer" point of contact for the authorized device must be identified and available at all times during GPS re-radiator operations.
Stop buzzer contacts are provided in the next section.

Stop Buzzer Contacts

Primary Stop Buzzer:

Robert Withrow

Desk: 661-824-6558

Mobile: 617-899-1574

Secondary Stop Buzzer:

Peter Kalogiannis

Desk: 661-824-6313

Mobile: 661-750-2431

System technical description

Scaled will be using a **GPS Source** “GLI-Metro Kit” to re-radiate external GPS L1 and L2 signals inside Hangar 78 at Mojave Air and Space Port. Technical descriptions of each of these components are attached to the application.

Hangar 78 is located at latitude 35.056726 longitude -118.160793 on taxiway C at Mojave Air and Space Port in Mojave California, 93561. A picture of the hangar location is shown in Figure 2 - Location of Hangar 78. This hangar is located at least 750 feet from the nearest runway at the airport.



Figure 2 - Location of Hangar 78

This GPS re-radiation system comprises:

- A roof-mounted L1L2-2GA active antenna,
- A GLI-METRO “smart” GPS amplifier and controller, and
- An internally mounted L1L2-2GP passive antenna.
- Coaxial feedline cables.
- An illuminated wall-mounted power switch.

A diagram of the system is included in Figure 3 - GPS re-radiation system diagram.

GPS Re-Radiation System Diagram

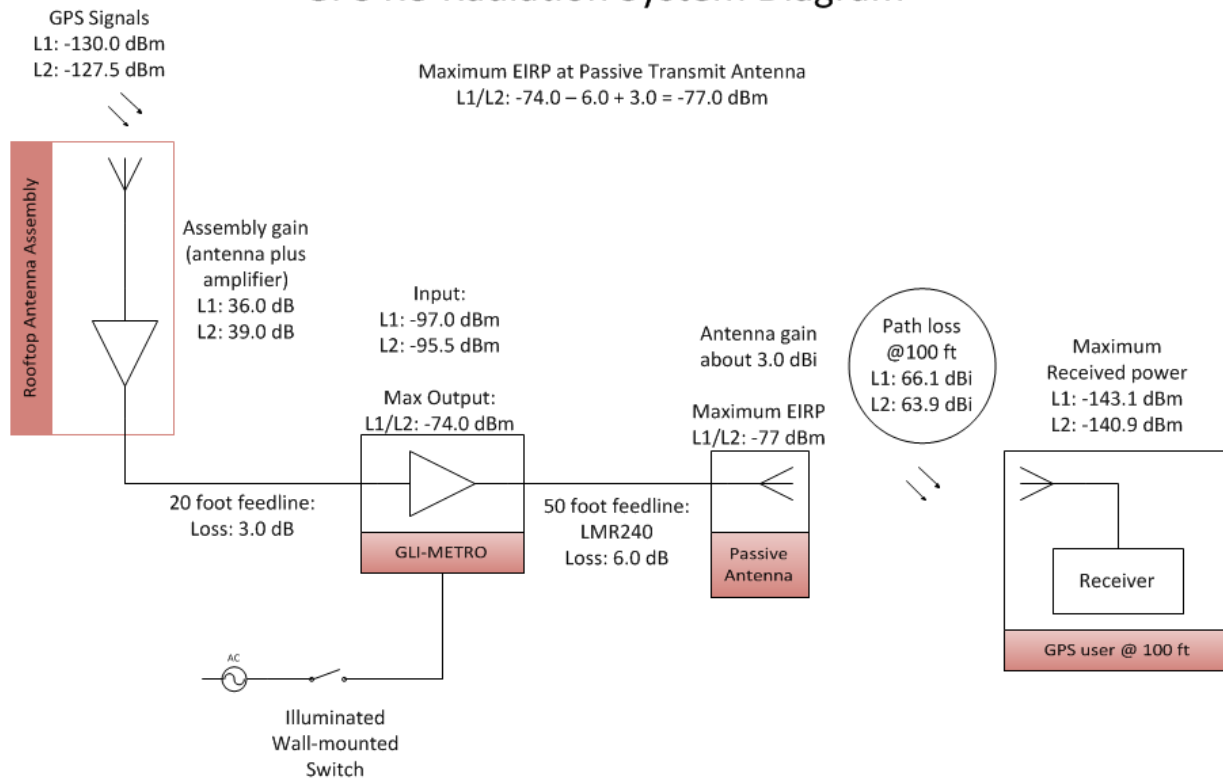


Figure 3 - GPS re-radiation system diagram

GPS signals are received and amplified by the active rooftop antenna. The amplified signals are conducted through a 20 foot coaxial cable to the GLI-METRO smart amplifier. The output of this amplifier is conducted through 50 foot low-loss coaxial cable to the passive antenna which re-radiates the signals.

The roof mounted active antenna provides gain which compensates for the loss in the 20 foot cable leading to the GLI-METRO device, and improves the S/N ratio at the input of the amplifier. The gains are as follows:

- For the L1 signal, the antenna provides about 3 dB element gain and 33 dB amplifier gain for a total gain of about 36 dB.
- For the L2 signal, the antenna provides about 6 dB element gain and 33 dB amplifier gain for a total gain of about 39 dB.

The GLI-METRO device is the heart of the system. Unlike a typical GPS amplifier, it regulates power *output* so that maximum EIRP is regulated. It requires a power input of between -155 and -85 dBm and produces a *regulated* power output of between -85 and -65 dBm. The combination of the regulated power output and the various self-test capabilities greatly reduces the risk of harmful interference to other GPS users.

The GLI-METRO comprises the following features:

- Filters that pass only the L1 and L2 GPS signals.
- Precise control of the output signal level (-85 to -65 dBm) such that the re-radiated power levels are below the NTIA maximum of -140 dBm/24 MHz at 100 ft.
- Oscillation detection and mitigation to prevent harmful interference due to malfunctioning components.
- Built in testing which alerts and mitigates:
 - High gain
 - Low gain
 - Short/Open circuit
 - Internal component failures
 - Inadequate input signal conditions

The passive antenna is mounted in the top front of the hangar facing the rear of the hangar and is position such that the re-radiated GPS signals are usable by all the aircraft and equipment inside the hangar. This is shown in Figure 4 - Location of antenna in hangar.



Hangar 78

1624 Flight Line

Figure 4 - Location of antenna in hangar

The system is powered by an illuminated wall switch at the side of the hangar. The illuminated switch provides indication that the system is operating and helps assure the system is only operational when needed for GPS system testing.

EIRP Computation

Unlike many other GPS signal amplifiers, the GLI-METRO regulates *output power*. As long as the input power is within the acceptable range of -115 to -85 dBm it will produce the installer-set regulated output power of -85 to -65 dBm. As a result, the output EIRP of the system is based *only* on the following items:

- The power output setting of the GLI-METRO, which we compute as being -74 dBm or less.
- The loss of the feedline from the output of the GLI-METRO to the passive transmitting antenna, which we compute as about 6 dB.
- The directivity gain of the transmitting antenna, which is stated by the manufacturer as about 3 dBi.

The GLI-METRO device will enter a fault condition if the input power is outside of the acceptable range and will inhibit the amplification of the GPS signals so as to eliminate the risk of harmful interference.

Note: The GLI-METRO device will be adjusted during installation to produce *the minimum power necessary* to perform the required testing with the maximum power being that shown in the analysis above and results in radiated signals with the NTIA limits.

Path loss to a distant isotropic receiver is computed as $PL = -37.88 + 20 \log(F_{\text{MHz}}) + 20 \log(d_{\text{ft}})$. For L1 the path loss at 100 feet is 66.1 dB and for L2 the path loss is 63.9 dB.

System use

This system will be operated *only* when GPS equipment testing is being performed. The illuminated wall-mounted power switch will be activated by the aircraft technician or engineer conducting the test and will be deactivated with the testing is complete. The switch illumination helps remind the technicians/engineers that the system is in operation.

The GLI-METRO device monitors a number of parameters and mitigates equipment failures so as to greatly reduce the risk of harmful interference to other GPS users.